

TECHNICAL NEWS BULLETIN

OF THE

NATIONAL BUREAU OF STANDARDS

ISSUED MONTHLY

Washington, August, 1931.—No. 172

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DESIGN OF INDUCTANCE STANDARDS

A report, which will be published in the August number of the BUREAU OF STANDARDS JOURNAL OF RESEARCH, discusses the design of standards of inductance for both laboratory and plant use. The paper deals with three distinct classes of reactors for different kinds of applications. The first class includes coils of wire which are wound on nonmagnetic cores to have definite values of inductance, and to serve as laboratory standards by which other inductance apparatus is checked. The second class includes very large inductance coils, commonly called current-limiting reactors, which are used in power plants to prevent the destruction of generators and other apparatus by short circuits. The third class of reactors differs from the other two in having the copper coil wound around an iron core having an air gap in its magnetic circuit. These iron-core reactors are used in various branches of electrical engineering.

Certain useful general relations apply to these three kinds of reactors and may be used to advantage in connection with their design. A list of these relations, a number of which have not been published hitherto, is given. They form the basis for a convenient and rapid method for the de-

sign of inductance standards, which is believed to be the first design procedure of this kind to be published. To obtain a given value of inductance while keeping the resistance below a certain permissible value, meanwhile using the minimum amount of conducting material for the coil, requires a particular optimum geometric form of coil. A form originally proposed by Maxwell, first used for standards of inductance by Wien in 1896, has been widely used. The less generally known modification of Maxwell's form described by Shawcross and Wells in 1915, is slightly better than Maxwell's, and is used in the design procedure of the paper.

With the design curves, which are given for both English and metric units, one can see at a glance the weight of copper and the size of the coil to obtain a given time constant, on the basis of round wire having ideal insulation of zero thickness. The diameter of the wire is also shown, on the assumption that the value of inductance desired is 1 millihenry, and an auxiliary curve gives values of a factor by which this diameter is to be multiplied to obtain the diameter for any other inductance in the range between 1 millihenry and 1 henry. Since actual insulation takes up space, one must use a larger coil of wire of larger diameter and greater weight

than the values given by the curves for ideal insulation. The procedure for the revision of the ideal values to those for wires having a specified kind of insulation is simple and requires only slide-rule calculations.

Other subjects relating to standards of inductance, which are briefly discussed, include: Suitable materials for the spool on which the wire is wound, method of adjusting the standard, and the best method for assembling inductance coils in sets.

The general theorems which underlie the design procedure just mentioned are then used to show how small-model coils may be employed to predetermine the self-inductance and mutual inductance of large current-limiting reactors as a check on existing methods of design. It is shown that the translational force between two reactors during short circuit, which sometimes amounts to many tons, may be determined by measuring the force between two small-scale models. The remarkable fact is easily demonstrated that if the model coils have the same number of turns as the corresponding full-size coils, and are correspondingly placed, the force between the model coils will be the same for a given current as that between the full-size coils.

The last section of the paper deals with the iron-core reactor. The reasons for the use of an air gap in the core are given, and it is demonstrated that for a given maximum flux density in the core the desirable minimum power factor is obtained when the length of the gap is such as to make the copper loss equal to the iron loss. The use of model iron-core reactors is proposed, both as a check on present methods of design and as an independent basis of design. In conclusion, some interesting facts about iron-core reactors are quoted from a recent paper by F. Emde, of Vienna.

ELECTRICAL PROPERTIES OF FOREIGN AND DOMESTIC MICAS

A number of samples of mica, fairly representative of the major sources of the world's supply, have been tested at the bureau for dielectric constant, power factor, dielectric strength, and ability to withstand elevated temperatures. These micas consisted of ruby and green muscovites, biotite, and phlogopite obtained from Africa, Argentina, Brazil, Canada, Guatemala, India, Madagascar, and the United States. It was the purpose of this investigation to determine the average values of power factor, for example,

to be expected from the various grades of mica, as well as the normal variations from these averages which must be expected in commercial lots of mica. The data should be of interest to the producers of mica as well as to those who are called upon to set up specifications for the purchase of this material. The results of these tests, which will be described in full in the August number of the BUREAU OF STANDARDS JOURNAL OF RESEARCH, are as follows:

For clear ruby muscovite, in the frequency range from 100 to 1,000 kilocycles, a dielectric constant of 7.2 and a power factor of 0.02 per cent may be expected, on the average. Individual samples may be expected to vary, on the average from these values by ± 0.3 in dielectric constant and ± 0.01 per cent in power factor. Within this frequency range the dielectric constant and power factor of clear ruby muscovite are apparently independent of frequency. The presence of stains and inclusions so seriously affects the power factor as to render such stained micas unsuited for radio purposes. The power factor of phlogopite is also found to be so high as to render it unsuited for use in radio circuits. The power factor of both stained muscovite and phlogopite is shown to be a function of the frequency used in the test.

The dielectric strength of mica is found to be relatively unaffected by the presence of air bubbles and but slightly affected by the presence of moderate amounts of stains in the form of metallic oxides. Curves showing the average dielectric strength of various classes of mica as a function of the thickness of the specimen are included in the report.

With but two exceptions, all of the micas investigated were unaffected by an exposure to a temperature of 600° C. for 30 minutes. Above that temperature the phlogopites withstood heating better than the muscovites.

In none of these tests was it possible to make any distinction between the various micas based solely on the geographical origin of the samples.

RIPENING OF PHOTOGRAPHIC EMULSIONS

The literature on photographic emulsions, except for a few recent articles, gives the impression that an emulsion must be "ripened" to its full sensitivity before washing. At the bureau it has been found that actually it is not only possible but desirable to digest the emulsion after washing, thus multiply-

ing the speed by a factor of 20 or more in many cases. Fast emulsions without ammonia must be made in this way. An article, which will appear in the August number of the BUREAU OF STANDARDS JOURNAL OF RESEARCH, describes an extensive study of the after-ripening process in the photographic emulsion laboratory and gives emulsion formulas and experimental methods in full detail. After-ripening by digestion was studied with respect to the effects of (1) ripening before washing, (2) temperature, (3) bromide or chloride ion concentration, (4) hydrogen ion concentration, (5) gelatin-silver halide ratio, (6) make or batch of gelatin, (7) addition of known sensitizing materials, and (8) proportion of iodide in the silver halide. The results can be best explained by the theory that the photographic effects are the result of a chemical reaction or reaction similar to that of silver bromide with allyl thiocarbamide, although with the gelatin used in the experiments there were distinct quantitative differences from the results with pure sensitizers like allyl thiocarbamide. If the emulsions were not digested sufficiently before coating, there was a slow after-ripening of the finished plates, generally similar to that during digestion. Analytical determinations of the change in bromide ion concentration and in nonhalide silver during after-ripening indicate that there was chemical reaction roughly parallel to the photographic changes, but probably only a small part of the products of the reaction or reactions are photographically important.

COTTON PARACHUTES

The bureau, in cooperation with the National Advisory Committee for Aeronautics, has been studying cotton cloth as a substitute for silk for making parachutes in the event of an emergency curtailing the supply. Cotton yarn of high strength in proportion to its weight and otherwise specially suitable for parachute cloth was developed. Cloth woven from this yarn in the bureau's mill was equal or superior to parachute silk in strength and tear resistance, met the requirements with respect to air permeability, and weighed only a few tenths of an ounce per square yard more than the silk cloth. Practical trials of cotton parachutes carried out by the Navy Department clearly indicate that the cotton parachute closely approaches the silk parachute in performance as

to rate of descent, opening time, strength, and ability to function after storage in the pack for 60 days. The cotton cloth increased the weight of the equipment by 1 pound (from 18 to 19 pounds) an increase well within practical limits. A specification for cotton parachute cloth has been prepared, and cotton yarns suitable for this purpose are now being woven commercially in the United States.

As cotton parachutes have been in use for some time by commercial aviators on account of their lower cost, the results obtained from this investigation will be reassuring to them, while the military services, which use silk exclusively, are assured of a domestic source of supply in case of emergency.

AGING QUALITIES OF PAPER TOWELS

The bureau has been studying the aging quality of paper towels. The principal harmful effect of storage, as revealed by this investigation, was loss of absorptiveness. While the deterioration was confined to a relatively small number of products, in a few cases it was of considerable magnitude. An accelerated aging test which involved heating the towels has been found to be a reliable guide to the retention of absorptive quality during storage.

This investigation was undertaken at the request of a Government department which found that some towels had unsatisfactory absorptiveness after a few months' storage despite their compliance on delivery with the specification suggested by the bureau in its Circular No. 294. The study was made in cooperation with paper-towel manufacturers, who furnished the towels for the tests and assisted materially with information and advice.

Thirty samples, thoroughly representative of the current commercial products, and newly manufactured, were tested when received and retested at the end of each month for a period of six months. The changes in the properties of the towels under normal storage conditions were then compared with those which occurred when the towels were baked for varying periods of time at 100° C. The strength of the towels, as measured by the tensile breaking test, remained quite constant during storage. The towels that best retained their absorptiveness had low rosin content, low acidity, and long, clean fibers. There was no constant relation between loss of absorptiveness and species of fiber or the degree of its

purification. The effects of 6-months' storage, which appears to be a sufficient period for the occurrence of any serious deterioration, was satisfactorily duplicated by baking the towels for one hour at 100° C.

A comparison of these recent tests with those made in 1925 shows that there has been a decided trend toward increased weight, decreased size, and better absorptive quality.

LUBRICATION OF CLOCKS AND OTHER DELICATE MECHANISMS

In cooperation with the Clock Manufacturers Association of America, the bureau has been investigating the lubrication of delicate mechanisms, such as clocks and watches, aeronautical instruments, etc. The importance of this subject has increased greatly with the increase in number and diversity of these instruments. Many are ruined and much money is lost by unsatisfactory lubrication.

The following suggestions are offered as criteria by which to judge suitability of a lubricant: (1) Availability; (2) chemical stability; (3) corrosive action on metals; (4) tendency to escape from pivots by spreading or by evaporation; (5) friction-reducing properties; and (6) temperature-viscosity characteristics, including the properties of the oil at low temperatures.

The oil from the head and jaw of the porpoise and the blackfish has for many years been found to conform satisfactorily to most of these requirements, but at present can not be supplied in sufficient quantity to meet the demands, the price of the oil now being in the neighborhood of \$125 per gallon. The other fatty oils in general, such as olive oil, cottonseed oil, etc., are, as prepared at the present time, objectionable on the grounds of chemical instability, corrosive action on metals, and the relatively high temperature—not much below 0° C.—at which they solidify. The petroleum oils are open to the objection that they have a tendency to escape from the bearings by spreading out over the plates and bridges of the timepiece. They are also less effective in reducing friction than fatty oils under conditions such as those encountered in timepieces.

The most promising suggestions which have been put forth to overcome the above difficulties are as follows:

1. To increase the supply of porpoise-jaw oil by establishing fisheries or, more properly, whaling stations,

and by artificially propagating porpoises and blackfish.

2. To prevent the deterioration of olive oil, sperm oil, or some other plentiful fatty oil by the use of more scientific methods of preparation, or by incorporating a chemical into the oil to increase its stability.

3. To synthesize an oil which would be free from the limitations of fatty oils and mineral oils alike.

4. To use mixtures of petroleum oils and fatty oils, in order to obtain the benefits of the superior qualities of both classes of lubricants.

5. To treat the plates and bridges of the timepieces with a chemical which would prevent mineral oils from spreading, thus permitting the use of these otherwise satisfactory products.

TESTING OF TIMEPIECES

The bureau has just published a new circular, No. 392, entitled "Testing of Timepieces." This supersedes Circular No. 51, published in 1914, and gives detailed descriptions of the bureau's regular tests for timepieces, and also other information on watches and time.

The tests described are for pocket watches, stop watches, and chronometers, many of the tests having been developed within the last few years. Illustrations showing the variation from isochronism, and the results of temperature changes on the daily rates of timepieces make the value of the tests apparent. The tests themselves are divided into periods of several days each to cover the various specifications which the timepieces are required to meet.

Four tests are provided for pocket watches. These are known as: Class A, class B, railroad precision, and business precision. The class A and the railroad precision tests are intended for high-grade watches, and include tests in five positions, and at three temperatures. The class A test also includes a test for isochronism. The class B and the business precision tests are the corresponding tests for 3-position watches. All of these tests furnish excellent means of judging the workmanship and performance of the watch.

In the tests of stop watches, each watch is run several times for intervals of 30, 45, 60, and 300 seconds, the mean error for each interval being used in judging the performance. Combination watches (watch and stop watch) are also submitted to an additional test to determine the daily rate

in the vertical and horizontal positions.

The chronometer test was developed to supply a short test for the ordinary type of chronometer used by many jewelers and on board ship. The instrument is tested at three temperatures, each temperature being repeated several times, and for isochronism for 36 hours. The results allow a study of the recovery of the chronometer after each temperature change.

Besides the descriptions of the tests, this circular also gives definitions of terms used; some helpful suggestions on the use and care of a watch; a list of official stations sending out radio time signals, with information regarding the same; a brief statement concerning standard time and standard time zones; and information and directions governing the submission of timepieces for test. There are also several illustrations of the bureau's equipment for testing timepieces.

Copies of the circular may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 15 cents each.

PLIABILITY OF SMOOTH-SURFACED, ASPHALT PREPARED ROOFING

One of the requirements of Federal Specification No. 214 for smooth-surfaced, asphalt prepared roofing, medium and heavy weights, is that strips of the roofing 1 inch wide and 6 inches long, cut in the direction of the fiber grain, shall not crack when bent over a two-fifths inch mandrel, through an arc of 180°, at a temperature of 77° F., in approximately 2 seconds' time.

Because of the failure to meet this requirement of a large proportion of the samples recently tested, the Government has been practically unable to secure material which conforms to its specification, with the result that work has been delayed in a number of cases, causing additional expense to the Government, contractors, and roofing manufacturers.

In view of this situation, there has arisen a demand that the pliability requirement be made less severe, the argument being that the test is more drastic than necessary; that in actual use roofing of this type is not subjected to conditions as severe as the conditions of the test.

In an effort to determine whether or not it is possible to make roofing of this type which will conform to the

present pliability requirement, the record of samples tested at the bureau for a number of years has been investigated. Since the pliability requirement for medium and heavy heavy weight roofing is the same, results of tests on both weights of material have been grouped.

For the years 1922-1927, inclusive, with more than 150 samples tested, approximately 26 per cent failed on the pliability test; for the years 1928 and 1929, with 70 samples tested, approximately 53 per cent failed; and for the years 1930 and 1931, with over 60 samples tested, approximately 90 per cent failed.

Since the method of the test has not been changed during the period in question, the only conclusion possible is that roofing of this type manufactured to-day is less pliable than that manufactured in former years. No explanation of this change in pliability can be given, though it must be influenced by one or more of the following: Changes in the process of manufacture of the prepared roofing; changes in nature of the asphaltic materials used; and changes in the materials or methods of manufacture of the felt used.

It should be pointed out, in considering this change in pliability of this type of prepared roofing, that it is impossible to state whether the roofing manufactured to-day will last as long or longer than the more pliable material of previous manufacture. That can only be determined by experience. It is certain, however, that material manufactured now is quite different from that produced some years ago, and experience gained with the earlier material should be discounted for that reason.

ELEVATOR SAFETY CODE

The American Standard Safety Code for Elevators, Dumbwaiters, and Escalators has been under revision for some time and the revised edition was finally approved as an American Standard by the American Standards Association on July 9, 1931. This code has passed through several editions and is under the joint sponsorship of the American Institute of Architects, the National Bureau of Standards, and the American Society of Mechanical Engineers. The last-named society publishes the code, which can be obtained for \$1 per copy. Orders should be addressed to the American Society of Mechanical Engineers, 29 West Thirty-ninth Street, New York, N. Y.

The new edition of the code contains definite specifications for the testing of buffers and of holstway-door interlocks. It has been modernized in several particulars to keep pace with this rapidly developing industry. Extensive additions have been made to the list of definitions, and higher speeds than were formerly used have been recognized, as well as the possibilities of using double-deck cars.

BUILDING AND PLUMBING CODES

Letter Circular No. 306 of the National Bureau of Standards contains the results of a survey of the status of building codes and plumbing codes in cities and towns of 5,000 population and over. The age of these codes, which ones are under revision and the expected date of completion, subjects that are receiving attention, and other facts are presented. This information was gathered primarily for the use of the Department of Commerce Building Code Committee, but has also been found useful by other bodies interested in safe and economical requirements.

Copies will be sent to those having a real use for the information on application to the division of building and housing, National Bureau of Standards, Washington, D. C.

FIRE TESTS OF BUILDING MATERIALS

In a paper presented before the seventeenth annual meeting of the Building Officials' Conference of America in Toronto, an account was given of the bureau's fire-resistance activities. This work is of particular interest to the building official, since his duties consist in part in administering regulations intended to secure safety from fire.

The annual property loss from fire in the United States now approximates \$500,000,000, in addition to a life loss estimated to be between 6,000 and 8,000 per year, caused directly or indirectly by fire. Our per capita loss by fire is high as compared with the European loss even after allowance has been made for the difference in wealth per capita.

Laboratory research on fire resistance comes under four main divisions, namely, fire severity, furnace tests of materials and constructions, tests of fire-protection equipment, and tests having a bearing on methods for prevention of fire.

The fire-severity tests are concerned with a study of the fire itself and have to do with the temperature and dura-

tion that can obtain when given amounts and kinds of combustible building contents are burned. While the severity of fire would appear at first sight to be too indefinite for satisfactory determination, the problem can be simplified considerably by testing only under the conditions that produce the higher range of severity. Typical occupancies, using discarded furniture and equipment, were burned out in 1-story fire-resistive buildings ranging in size from a room 15 by 29 feet to 30 by 60 feet, the temperatures being measured from the start of the fire until the ruins cooled down. By introducing different amounts of materials a relation was obtained between the severity of the fire and the amount of combustible materials as computed in lbs./ft.² of floor area. This severity was calculated as equivalent to a given number of hours of exposure to the furnace test. Thus light occupancies with 10 lbs./ft.² of combustibles were found to give a fire severity equal approximately to the first hour of the furnace test, while heavier concentrations of 50 lbs./ft.² were found to give a fire equivalent to about six hours of the same test.

Building constructions, such as columns, floors, walls, and partitions, are tested for resistance to fire by subjection to fire exposure in a furnace, the temperature of which is controlled according to a prescribed schedule, so that a temperature of 1,700° F. is reached after 1 hour, with a rise thereafter reaching 2,000° F. in 4 hours, and 2,300° F. in 8 hours. Constructions designed to carry load in buildings are tested under such loads while exposed to fire. Using this procedure, tests have been made on structural steel; cast iron; reinforced concrete and timber columns, unprotected and protected with materials in several thicknesses. Fire tests have also been made of solid and hollow brick walls, hollow tile walls, and interior partitions, the tests with the latter being still in progress. Fire tests are also under way on a new type of welded-steel floor construction. This floor consists of a steel plate serving as the floor proper, welded to steel I beams spaced about 24 inches apart.

Comprehensive tests have been completed of roofing materials to determine resistance to burning brands and spread of flame. The compressive strength and other properties of structural steel and cast iron have been determined at temperatures up to 1,800° F. Similar tests have also been made with wood, one significant result found

being the large loss in strength that occurs near 212° F.

Tests of fire-protection equipment are generally conducted only at the request of other Government departments or to obtain information on which purchase specifications may be based. On this basis, tests have been made of insulated safes, fire extinguishers, fire hose, and automatic equipment for the detection and extinguishment of fire.

Of portions of the work which have a bearing on fire prevention, mention can be made of tests to determine the susceptibility of materials to ignition from spontaneous heating, the hazard of photographic, X ray, and motion-picture film, and tests to determine the conditions under which fires are caused by such agencies as discarded cigarettes, cigars, and matches. In connection with the last-named tests some modifications in the make-up of cigarettes and matches were developed that would decrease the hazard which now exists from discarding them before they are extinguished.

PROGRESS REPORT ON SOIL CORROSION

Eight years ago the bureau began a study of the relation of soils to the corrosion of pipe materials buried underground. A very large number of specimens of all of the commonly used materials were buried in 47 soils. At approximately 2-year intervals representative samples have been removed and the extent of the corrosion carefully determined. Such an examination was made during 1930, and the results, assembled and tabulated, were published in the July number of the BUREAU OF STANDARDS JOURNAL OF RESEARCH. In general, they confirm the conclusions reached after previous inspections, as reported in Technologic Paper No. 368. Throughout the eight years during which the specimens have been exposed, characteristics of the soil rather than of the ferrous materials have controlled the kind and extent of the corrosion. Because there is a possibility that at later periods differences in the materials will result in appreciable differences in rates of corrosion, the bureau believes that it should not make comparisons of materials at this time; moreover the data now available do not indicate that any one of these is best for all soil conditions. So far, materials which appear best under one soil condition have appeared inferior to some other material in a different soil.

Rates of corrosion vary somewhat from year to year because of settling of the trench in which the specimens were buried and changes in the supply of moisture. There is no constant relation between the rate at which specimens lose weight and the rate at which the depth of pits increases. Some soils cause the materials to pit badly, but the pitting results in comparatively little loss of weight. In other soils the corrosion is more uniformly distributed over the surface of the material, and a considerable loss of weight occurs with a low rate of penetration. As, in most installations of pipe, much thicker material is used than is necessary to withstand the pressure of the fluid carried, the loss of weight is not of great importance if uniformly distributed, but the formation of even a few deep pits may be a serious matter.

Rate of pitting, therefore, rather than rate of loss of weight is frequently the best indication of the corrosiveness of a soil. While data to be secured later may indicate relative merits of materials, the data so far obtained are chiefly valuable in connection with the study of field methods for determining soil corrosivity. When these methods are further developed it will be practicable to make a soil-corrosion survey, from the results of which the owner can tell whether he should use a corrosion-resistant pipe material or apply a protective coating to his line.

EFFECT OF HEAT TREATMENT ON ULTRA-VIOLET TRANSMISSION OF SPECIAL GLASSES

In a report to be published in the August number of the BUREAU OF STANDARDS JOURNAL OF RESEARCH data are given which show the relation between the ultra-violet transmissions of two commercial glasses (vita and helio glass) before and after solarization by ultra-violet radiations at ordinary temperatures and also after various heat treatments in the range 200° to 600° C.

It is shown that the highest ultra-violet transmission found for these glasses was obtained after heat treatments at temperatures in the annealing range; that is, somewhat above 500° C. Treatments at higher temperatures cause deformation and some surface deterioration, while those at lower temperatures are less effective in rejuvenating the glass, although treatments at temperatures as low as 300° C. often approximately restored

the transmissivity to its initial value on receipt of the glass.

Visible colorations, which on artificial solarization accompany the decrease in transmission of the shorter visible rays, apparently disappear completely upon relatively short heat treatments at temperatures no higher than 200° or 300° C. The visible thermo-luminescence accompanying this disappearance of the coloration, and apparently persisting only during the time required for the restoration of the transmission near the visible spectrum, was found to grow more intense and to continue for correspondingly shorter intervals as the temperature of heat treatment was raised.

Even after the visible coloration and thermo-luminescence had disappeared, as a result of heating at these low temperatures, the complete restoration of the transmission for the shortest wave lengths transmitted by these glasses required additional heat treatments near 500° C.

SPECIAL LOW-FIRE WHITE-WARE BODIES

With the development of means for electrical heating, the attention of the ceramic industry has been turned to the possibilities of adapting this source of heat to the firing of white ware. It has been proved practicable to fire ceramic ware electrically, but it would be an added economy and convenience if satisfactory bodies could be developed maturing at, or below, 1,000° C. Artificially compounded fluxes have been used for many years in special types of pottery to promote translucency or to lower the maturing temperature, and a study was undertaken to determine the possibilities of developing an earthenware or a vitrified product having the maturing characteristics referred to. For the preliminary work, 28 glasses, or frits, were prepared according to the basic formula $RO:1.3 R_2O_3:1.7 RO_n$, using the following oxides: Na_2O , MgO , SrO , ZnO , CaO , Al_2O_3 , B_2O_3 , Sb_2O_3 , P_2O_5 , SiO_2 , and ZrO_2 ; fluorine, as a constituent of cryolite, was also used in five of the glasses. Six of these fluxes were found suitable for intensive study. According to calculation their tensile strengths vary from 26 to 32 kg/mm², moduli of elasticity from fifty-seven to seventy-six hundred kg/mm², and the observed thermal expansions (in terms of coefficient) vary from 5 to 11 $\times 10^{-6}$. Bodies were prepared which could be successfully dry pressed or cast, but it was found im-

practicable to form ware by "jiggering." The bodies mature at from 950° to 975° C.; although no coloring oxides were used, the color varied from dark cream to white, depending on the flux used. At 950° C. the absorption varied from 3.5 to 8 per cent, at 975° C. from 0.2 to 6.1 per cent. Maximum strength (modulus of rupture in lbs./in.² was 4,945; the average at 950° C. was 4,090; at 975° C., 4,560. Specimens of tile and cast ware were successfully glazed and pieces produced which withstood the autoclave test (150 lbs./in.² for one and one-half hours) for resistance to crazing.

LIFE OF SAGGERS AS RELATED TO PROPERTIES

The sixth of a series of progress reports dealing with the bureau's investigation of sagger clays is being prepared for publication. The results obtained in the most recent phase of this study may be summarized as follows:

From 5 to 15 small saggars were made from each of 35 laboratory-prepared sagger bodies and from each of 10 commercially prepared bodies. The 35 bodies were prepared from combinations of 28 different clays, some of which were used only as the bond, others as both grog, obtained after firing, and bond. The majority of the bodies were made in two series, one of which was prepared with coarse grog and the other with fine grog. The saggars were tested for resistance to heat shock after firing at one or all three of the following temperatures, namely, 1,190°, 1,230°, and 1,270° C. Specimen bars were made to correspond with each set of saggars and fired simultaneously with the saggars. These bars were used for determining linear thermal expansion from 20° to 1,000° C., porosity, moduli of elasticity, and rupture and plastic flow at 1,000° C.

The data show that increases in the temperature of firing, although evidenced by comparatively small decreases in the porosity of the sagger bodies, may cause great increases in the modulus of elasticity. This in turn affects the maximum fiber elongation unfavorably and thereby decreases the resistance of saggars to failure from thermal shock.

The linear thermal expansion of the bodies changes with increase of temperature of firing, but such changes are not consistently either in the same direction or of the same magnitude.

Data show the importance of controlling, first, the linear thermal ex-

pansion; and, second, the maximum fiber elongation if it is desired to obtain a high resistance of saggars to failure due to thermal shock. A total linear thermal expansion from 20° to 250° C. of approximately 0.18 per cent or greater practically precludes the possibility of obtaining a sagger having a high resistance to thermal failure. The life of the sagger is more sensitive to changes in thermal expansion than to changes in the computed outer fiber elongation.

The plastic flow studies at 1,000° C. show that: (1) Bodies containing the coarse sizes of grog have plastic deflections decidedly greater than those containing the finer grog sizes; (2) the plastic flow decreases with increase of temperature of firing of the specimens; and (3) the flux content is an important factor in the tendency of the bodies to flow or deform at high temperatures, and is more serious if the silica content is high.

The results show that it is very desirable to analyze the conditions of service under which saggars are to be used, because in most cases it is impossible to prepare sagger bodies from the usual run of clays which have properties ideally suited for longevity in all types of service. By studying the properties of the finished sagger body and the clays and grog constituting it, it is possible to make quality saggars limited only by the character of the materials used.

NEW AND REVISED PUBLICATIONS ISSUED DURING JULY, 1931

*Journal of Research*¹

Bureau of Standards Journal of Research, vol. 7, No. 1, July, 1931. (RP Nos. 329 to 338, inclusive.) Price, 40 cents. Obtainable by subscription.

*Research Papers*¹

(Reprints from Journal of Research)

RP303. Note on contraction coefficients of jets of gas. Edgar Buckingham. Price 5 cents.

¹ Send orders for publications under this heading with remittance only to the Superintendent of Documents, Government Printing Office, Washington, D. C. Subscription to Technical News Bulletin, 25 cents per year (United States and its possessions, Canada, Cuba, Mexico, Newfoundland, and Republic of Panama), other countries, 40 cents. Subscription to Journal of Research, \$2.75 per year; other countries, \$3.50. Subscription to Commercial Standards Monthly, \$1 per year; other countries, \$1.25.

RP304. The effect of small variations in pitch upon the inductance of a solenoid. Chester Snow. Price 5 cents.

RP305. Heat content values for aqueous solutions of the chlorides, nitrates, and hydroxides of hydrogen, lithium, sodium, and potassium at 18° C. Frederick D. Rossini. Price 5 cents.

RP306. Accurate measurement of small electric charges by a null method. Lauriston S. Taylor. Price 10 cents.

RP307. Light sensitivity of rosin paper-sizing materials. Arthur E. Kimberly and J. F. G. Hicks. Price 5 cents.

RP308. Dimensional changes in the manufacture of electrotypes. N. Bekkedahl and W. Blum. Price 10 cents.

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LETTER CIRCULARS*

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OUTSIDE PUBLICATIONS*

- A simple time meter. H. B. Brooks; Review of Scientific Instruments (Ithaca, N. Y.), vol. 2, No. 6, p. 348; June, 1931.
- Bibliography on radio wave phenomena and measurement of radio field intensity. T. Parkinson, F. S. Kirby, P. N. Arnold, and E. M. Zandonini; Proceedings Institute of Radio Engineers (New York, N. Y.), vol. 19, p. 1034; June, 1931.
- Means to avoid electrical shock are described. Arthur Halsted; United States Daily (Washington, D. C.), vol. 6, No. 101, p. 4; June 30, 1931.
- Electrical accidents in the home. M. G. Lloyd; Insurance (Newark, N. J.), vol. 95, No. 12, p. 213; May 15, 1931.
- Defective equipments cause low-voltage failures. M. G. Lloyd; Electrical World (New York, N. Y.), vol. 98, No. 3, p. 116; July 18, 1931.
- Gasoline dopes. H. C. Dickinson; Industrial and Engineering Chemistry (Washington, D. C.), vol. 23, No. 5, p. 517; May, 1931.
- Freezing and boiling points of the ternary system ethanol-methanol-water. El. W. Aldrich and D. W. Querfeld; Industrial and Engineering Chemistry (Washington, D. C.), vol. 23, No. 6, p. 708; June, 1931.
- The gaseous explosive reaction. F. W. Stevens; The Scientific Monthly (New York, N. Y.), vol. 32, p. 556; June, 1931.

¹ See footnote on p. 91.

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The spectral erythemic reaction of the human skin to ultra-violet radiation. W. W. Coblenz, R. Stair, and J. M. Hogue; Proceedings, National Academy of Sciences (Washington, D. C.), vol. 17, No. 6, p. 401; June, 1931.

Providing chemists with adequate tools. Edward Wichers; United States Daily (Washington, D. C.), vol. 6, No. 98, p. 10; June 26, 1931.

More altitude flights. H. B. Hendrickson; Aero Digest (New York, N. Y.), vol. 19, No. 1, p. 36; July, 1931.

Classification of the fastness of dyed textiles in the standard sunlight exposure test. W. H. Cady, W. C. Smith, and W. D. Appel; American Dyestuff Reporter (New York, N. Y.), vol. 20, p. 359; June 8, 1931.

Some physical properties of fur-seal skins. R. C. Bowker; Journal Technical Association of the Fur Industry (Brooklyn, N. Y.), vol. 2, No. 2, p. 34; June, 1931.

Analyses of salt used for curing hides and skins. R. C. Bowker and John Beek, Jr.; Journal American Leather Chemists' Association (Ridgway, Pa.), vol. 26, No. 6, p. 312; June, 1931.

Properties of the rare metals for high-temperature service. W. H. Swanger; Preprint of paper before American Society for Testing Materials (Philadelphia, Pa.), June, 1931.

Oxygen as a factor in submerged corrosion. E. C. Groesbeck and S. J. Waldron; Preprint of paper before American Society for Testing Materials (Philadelphia, Pa.), June, 1931.

Fatigue testing of wire. S. M. Shelton; Preprint of paper before American Society for Testing Materials (Philadelphia, Pa.), June, 1931.

Thermomagnetic analysis and the α transformation in 0.75 per cent carbon steel. R. L. Sanford and G. A. Ellinger; Preprint of paper before American Society for Testing Materials (Philadelphia, Pa.), June, 1931.

On the direct determination of soda in soda-lime glasses by precipitation as uranyl zinc sodium acetate. F. W. Glaze; Journal American Ceramic Society (Columbus, Ohio), vol. 14, No. 6, p. 450; June, 1931.

Comparative tests for determining resistance of fire-clay brick to thermal spalling. R. A. Heindl; Preprint of paper before American Society for Testing Materials (Philadelphia, Pa.), June, 1931.

Weathering test procedures for stone. D. W. Kessler; Preprint of paper before American Society for Testing Materials (Philadelphia, Pa.), June, 1931.

Bibliography on weathering of natural stone. D. W. Kessler; Preprint of paper before American Society for Testing Materials (Philadelphia, Pa.), June, 1931.

Results of freezing and thawing tests on sand-lime brick. H. F. McMurdie; Rock Products (Chicago, Ill.), p. 3; June 6, 1931.

